



1
00:00:00,790 --> 00:00:07,320

[Music]

2
00:00:12,010 --> 00:00:08,970

[Applause]

3
00:00:13,510 --> 00:00:12,020

and my intent was to start with the

4
00:00:16,090 --> 00:00:13,520

acknowledgments upfront in case I don't

5
00:00:17,260 --> 00:00:16,100

get there later and that is to say that

6
00:00:18,640 --> 00:00:17,270

this is sort of an integrated effort

7
00:00:21,189 --> 00:00:18,650

from part of the rocket-powered life

8
00:00:24,999 --> 00:00:21,199

team and we thank the NASA Astrobiology

9
00:00:27,040 --> 00:00:25,009

Institute for funding and my goal today

10
00:00:28,990 --> 00:00:27,050

is going to be to integrate data that's

11
00:00:30,609 --> 00:00:29,000

come from several different students

12
00:00:33,040 --> 00:00:30,619

that have been working on various

13
00:00:35,200 --> 00:00:33,050

aspects of the system so you'll see me

14

00:00:38,050 --> 00:00:35,210

refer to them but this is taking just

15

00:00:39,970 --> 00:00:38,060

some of the snapshots of current

16

00:00:41,530 --> 00:00:39,980

information from a variety of different

17

00:00:43,960 --> 00:00:41,540

studies looking at both the geochemistry

18

00:00:45,370 --> 00:00:43,970

and integrated microbiology derive from

19

00:00:50,110 --> 00:00:45,380

each of these students and postdocs

20

00:00:51,790 --> 00:00:50,120

right now so the system that I'm going

21

00:00:53,560 --> 00:00:51,800

to talk about today is derived from just

22

00:00:56,110 --> 00:00:53,570

one of the sites that we work on in our

23

00:00:58,120 --> 00:00:56,120

pl I'm specifically going to look at the

24

00:00:59,650 --> 00:00:58,130

OMA know feel light and the reason here

25

00:01:01,450 --> 00:00:59,660

is that I'm trying to look into the

26

00:01:04,600 --> 00:01:01,460

subsurface of a system where we have an

27

00:01:07,240 --> 00:01:04,610

enormous volumetric amount of peridotite

28

00:01:10,050 --> 00:01:07,250

that's not dramatically impacted by

29

00:01:12,790 --> 00:01:10,060

other lithology surrounding it and so

30

00:01:14,350 --> 00:01:12,800

what we're able to do is to look into a

31

00:01:16,720 --> 00:01:14,360

subsurface environment where the

32

00:01:18,880 --> 00:01:16,730

peridotite is an aquifer that's active

33

00:01:21,640 --> 00:01:18,890

it's storing fluids and those fluids are

34

00:01:23,380 --> 00:01:21,650

in the 30 to 50 degrees C range and they

35

00:01:24,550 --> 00:01:23,390

have abundant hydrogen so I'm not going

36

00:01:26,200 --> 00:01:24,560

to be talking about the generation of

37

00:01:27,700 --> 00:01:26,210

that hydrogen today but rather to say

38

00:01:30,399 --> 00:01:27,710

everywhere we look we have anywhere from

39

00:01:32,560 --> 00:01:30,409

micro molar 2 milli molar concentrations

40

00:01:34,810 --> 00:01:32,570

of hydrogen and that is being modulated

41

00:01:36,340 --> 00:01:34,820

again by not only the geochemical

42

00:01:41,950 --> 00:01:36,350

dynamics but the microbial activity

43

00:01:43,690 --> 00:01:41,960

within the subsurface and in terms of

44

00:01:45,940 --> 00:01:43,700

linking this to some of the systems that

45

00:01:48,700 --> 00:01:45,950

I think this information is going to be

46

00:01:50,530 --> 00:01:48,710

relevant for I wanted to put up both of

47

00:01:52,630 --> 00:01:50,540

these slides today so when we talk about

48

00:01:54,969 --> 00:01:52,640

looking at subsurface life in a pretty

49

00:01:58,330 --> 00:01:54,979

tight in let's say in icy world's

50

00:02:00,789 --> 00:01:58,340

context most the time at least for what

51
00:02:02,740 --> 00:02:00,799
we're working on in in the Oman system

52
00:02:05,230 --> 00:02:02,750
we're not discussing really the ocean

53
00:02:08,619 --> 00:02:05,240
and the possible biological activity in

54
00:02:10,539 --> 00:02:08,629
the ocean system or the under surface of

55
00:02:12,190 --> 00:02:10,549
the ice although serpentinization the

56
00:02:14,339 --> 00:02:12,200
process we're studying is well known to

57
00:02:17,170 --> 00:02:14,349
modulate potentially the ocean chemistry

58
00:02:18,200 --> 00:02:17,180
rather we're interested in imagining

59
00:02:19,880 --> 00:02:18,210
what may occur in the

60
00:02:22,190 --> 00:02:19,890
rakh hosted environment and what those

61
00:02:24,230 --> 00:02:22,200
habitable niches are as you have fluid

62
00:02:26,150 --> 00:02:24,240
ingress and circulation at temperatures

63
00:02:27,680 --> 00:02:26,160

that are non hydrothermal so we're

64

00:02:29,960 --> 00:02:27,690

looking at what would be represented by

65

00:02:33,650 --> 00:02:29,970

large volumes of rock again but it away

66

00:02:34,970 --> 00:02:33,660

from a high heat source when we talk

67

00:02:37,100 --> 00:02:34,980

about Mars which is something that I

68

00:02:39,380 --> 00:02:37,110

refer to really briefly in part of the

69

00:02:41,330 --> 00:02:39,390

plenary yesterday in this particular

70

00:02:44,120 --> 00:02:41,340

case we're interested in our system in

71

00:02:45,410 --> 00:02:44,130

the more static component of the

72

00:02:47,210 --> 00:02:45,420

subsurface environment and I'll

73

00:02:48,650 --> 00:02:47,220

differentiate that today and these are

74

00:02:51,080 --> 00:02:48,660

areas where we're really not having

75

00:02:53,870 --> 00:02:51,090

aggressive fluid circulation or exchange

76

00:02:55,160 --> 00:02:53,880

it's relatively sealed system but we

77

00:02:57,170 --> 00:02:55,170

would like to know if you're again you

78

00:02:59,420 --> 00:02:57,180

had a subsurface aquifer on Mars and you

79

00:03:02,120 --> 00:02:59,430

had hydrogen stored or generated in that

80

00:03:04,280 --> 00:03:02,130

condition what is it required to allow

81

00:03:06,470 --> 00:03:04,290

biological activity to persist over long

82

00:03:08,270 --> 00:03:06,480

periods of time and if that should

83

00:03:10,310 --> 00:03:08,280

happen what would be both the signals of

84

00:03:12,290 --> 00:03:10,320

that extant life or again if it was to

85

00:03:14,390 --> 00:03:12,300

be preserved or fossilized what would we

86

00:03:16,190 --> 00:03:14,400

expect to see is those signals so

87

00:03:18,110 --> 00:03:16,200

contextually again I just keep coming

88

00:03:20,240 --> 00:03:18,120

back to where water rock interaction but

89

00:03:21,680 --> 00:03:20,250

under highly rock dominated conditions

90

00:03:23,900 --> 00:03:21,690

but trying to understand the microbial

91

00:03:26,720 --> 00:03:23,910

activity and preservation under that

92

00:03:28,670 --> 00:03:26,730

state so if I'm lucky now its own maybe

93

00:03:31,540 --> 00:03:28,680

almost about 2:30 and I could just talk

94

00:03:37,580 --> 00:03:35,390

okay so Oman system in cartoon format

95

00:03:39,290 --> 00:03:37,590

when I show this type of a picture of

96

00:03:41,630 --> 00:03:39,300

the surface environment of peridotite

97

00:03:43,550 --> 00:03:41,640

that would sort of be here looking at a

98

00:03:44,990 --> 00:03:43,560

mountain landscape what we're interested

99

00:03:47,570 --> 00:03:45,000

in is looking then again at the

100

00:03:50,030 --> 00:03:47,580

hydrology in the rock system in the

101
00:03:51,590 --> 00:03:50,040
steeper subsurface and we've been really

102
00:03:53,420 --> 00:03:51,600
fortunate to have access to the

103
00:03:55,430 --> 00:03:53,430
subsurface through pre-existing Legacy

104
00:03:56,810 --> 00:03:55,440
boreholes and that's a way that we're

105
00:03:59,330 --> 00:03:56,820
able to pull fluids out of the

106
00:04:01,760 --> 00:03:59,340
subsurface over a diverse array of

107
00:04:04,220 --> 00:04:01,770
conditions as well as targeted drilling

108
00:04:06,410 --> 00:04:04,230
in the last year in 2018 that has

109
00:04:08,120 --> 00:04:06,420
allowed us to pull and recover core over

110
00:04:11,330 --> 00:04:08,130
many hundreds of meters in multiple

111
00:04:12,710 --> 00:04:11,340
locations and those bore holes are again

112
00:04:15,050 --> 00:04:12,720
the cored rocks they're penetrating

113
00:04:17,510 --> 00:04:15,060

different parts of a hydrological regime

114

00:04:19,640 --> 00:04:17,520

so there's a shallow flow system shorter

115

00:04:21,110 --> 00:04:19,650

residence time residence time fluids

116

00:04:23,300 --> 00:04:21,120

moving through a fracture network in

117

00:04:25,220 --> 00:04:23,310

habitable conditions generated here and

118

00:04:26,630 --> 00:04:25,230

James long gave a great talk earlier

119

00:04:28,760 --> 00:04:26,640

this week about some of the geochemical

120

00:04:30,530 --> 00:04:28,770

states of that system but we're also

121

00:04:31,730 --> 00:04:30,540

really interested in the ability of life

122

00:04:33,500 --> 00:04:31,740

to persist and be

123

00:04:35,810 --> 00:04:33,510

and thrive and be active and preserved

124

00:04:37,670 --> 00:04:35,820

in the deeper parts here which I'm going

125

00:04:42,800 --> 00:04:37,680

to call the more closed system it's more

126
00:04:45,050 --> 00:04:42,810
hyper alkaline and highly reducing from

127
00:04:46,460 --> 00:04:45,060
having pulled a lot of fluids out year

128
00:04:48,350 --> 00:04:46,470
after year and across the different

129
00:04:50,120 --> 00:04:48,360
parts of the system we do know a lot

130
00:04:52,430 --> 00:04:50,130
about who the dominant organisms at

131
00:04:54,020 --> 00:04:52,440
least are biologically so kitty Rumford

132
00:04:56,240 --> 00:04:54,030
published a paper and following on from

133
00:04:58,820 --> 00:04:56,250
Hannah Miller really identifying for

134
00:05:01,130 --> 00:04:58,830
example a CEO thermia affirmative self

135
00:05:02,630 --> 00:05:01,140
of ibrahim athena bacterium several

136
00:05:05,560 --> 00:05:02,640
different organisms is some of the

137
00:05:08,690 --> 00:05:05,570
dominant like an methane sita genic

138
00:05:10,580 --> 00:05:08,700

sulfur cycling and nitrogen cycling taxa

139

00:05:12,140 --> 00:05:10,590

that are present now they're

140

00:05:13,940 --> 00:05:12,150

differentially distributed and more

141

00:05:15,260 --> 00:05:13,950

still trying to probe them the activity

142

00:05:16,820 --> 00:05:15,270

of different organisms in different

143

00:05:20,660 --> 00:05:16,830

states of the system to understand that

144

00:05:22,460 --> 00:05:20,670

role if we take one environment we're

145

00:05:24,350 --> 00:05:22,470

really profiling as a function of depth

146

00:05:26,270 --> 00:05:24,360

and we look at the different geochemical

147

00:05:28,250 --> 00:05:26,280

states of the system this is where we're

148

00:05:29,990 --> 00:05:28,260

in a sub oxic moderately reducing

149

00:05:32,150 --> 00:05:30,000

environment that we can find often in

150

00:05:34,610 --> 00:05:32,160

the shallower parts that upper tens of

151
00:05:36,080 --> 00:05:34,620
meters in the fractured aquifer but as

152
00:05:38,420 --> 00:05:36,090
soon as we get into a part of the system

153
00:05:39,620 --> 00:05:38,430
that again has a lot less fluid transfer

154
00:05:42,500 --> 00:05:39,630
that's occurring through it's more

155
00:05:44,150 --> 00:05:42,510
static and closed we rapidly drive down

156
00:05:46,850 --> 00:05:44,160
to the lower stability of lot water

157
00:05:47,990 --> 00:05:46,860
limit of water and are held there and so

158
00:05:49,700 --> 00:05:48,000
we actually have a huge amount of data

159
00:05:52,130 --> 00:05:49,710
that sits right down here but we can

160
00:05:53,450 --> 00:05:52,140
span these conditions when we pump

161
00:05:55,460 --> 00:05:53,460
fluids sorry about that

162
00:05:57,290 --> 00:05:55,470
and when we pump fluids we're pumping

163
00:05:59,240 --> 00:05:57,300

all of this up together and integrating

164

00:06:00,530 --> 00:05:59,250

it into that community so a lot of our

165

00:06:02,840 --> 00:06:00,540

goals at the moment have been to

166

00:06:05,030 --> 00:06:02,850

actually as a function of depth and in

167

00:06:07,040 --> 00:06:05,040

geochemical environments to separate

168

00:06:08,330 --> 00:06:07,050

this out better but if we're in the

169

00:06:09,560 --> 00:06:08,340

surface environment where there's a lot

170

00:06:11,660 --> 00:06:09,570

of fluid mixing going on

171

00:06:13,250 --> 00:06:11,670

nitrate it's our most dominant electron

172

00:06:15,380 --> 00:06:13,260

acceptor and so kitty our efforts been

173

00:06:18,590 --> 00:06:15,390

trying to trace the prevalence of

174

00:06:20,150 --> 00:06:18,600

nitrate and then we have full conversion

175

00:06:22,130 --> 00:06:20,160

to ammonia so this becomes a highly

176
00:06:23,660 --> 00:06:22,140
reducing system high ammonia fluids and

177
00:06:26,510 --> 00:06:23,670
the look at the differential gene

178
00:06:28,280 --> 00:06:26,520
abundance for nitrogen cycling the idea

179
00:06:29,630 --> 00:06:28,290
here would be although we have nitrate

180
00:06:31,700 --> 00:06:29,640
and some of these sort of more shallow

181
00:06:32,690 --> 00:06:31,710
mixing systems it's really not playing a

182
00:06:35,360 --> 00:06:32,700
role deeper down

183
00:06:36,950 --> 00:06:35,370
we do have sulfate throughout we often

184
00:06:39,860 --> 00:06:36,960
have sulfate in excess that's not being

185
00:06:41,690 --> 00:06:39,870
fully consumed we do lose our di si but

186
00:06:44,300 --> 00:06:41,700
we do have partially carbonated rocks

187
00:06:45,080 --> 00:06:44,310
and each of these set a state of the

188
00:06:49,159 --> 00:06:45,090

system that's

189

00:06:50,840 --> 00:06:49,169

interesting to probe biologically and

190

00:06:52,280 --> 00:06:50,850

some work published this year by Libby

191

00:06:53,840 --> 00:06:52,290

phones one of the things that were able

192

00:06:55,310 --> 00:06:53,850

to see is that no matter where we've

193

00:06:56,330 --> 00:06:55,320

been pulling fluids from in this more

194

00:06:58,400 --> 00:06:56,340

integrated fashion

195

00:07:00,260 --> 00:06:58,410

we're often sitting at about 10 to the 5

196

00:07:02,600 --> 00:07:00,270

cells per mil this is actually a

197

00:07:04,100 --> 00:07:02,610

surprisingly robust microbial population

198

00:07:08,420 --> 00:07:04,110

that we're seeing in the fluid system

199

00:07:10,040 --> 00:07:08,430

throughout and it's true even when we're

200

00:07:14,659 --> 00:07:10,050

in these more hyper alkaline fluids

201
00:07:16,310 --> 00:07:14,669
meaning once we're above pH of 10 and in

202
00:07:18,110 --> 00:07:16,320
the same study one of the things that

203
00:07:22,010 --> 00:07:18,120
Libby was working on was trying to probe

204
00:07:23,450 --> 00:07:22,020
both the reduction of co2 into through a

205
00:07:25,730 --> 00:07:23,460
variety of different pathways and it's

206
00:07:27,620 --> 00:07:25,740
assimilation into biomass in this

207
00:07:29,540 --> 00:07:27,630
particular assay what she was doing was

208
00:07:31,219 --> 00:07:29,550
trying to take 14 labeled bicarbonate

209
00:07:33,770 --> 00:07:31,229
and look at its conversion to methane to

210
00:07:35,390 --> 00:07:33,780
detect active Nathanael Genesis again

211
00:07:37,460 --> 00:07:35,400
what she can see is that there's active

212
00:07:39,200 --> 00:07:37,470
magenta thany Genesis through all the

213
00:07:42,200 --> 00:07:39,210

different pH and water chemistry's of

214

00:07:44,450 --> 00:07:42,210

the system although you know leave it

215

00:07:46,480 --> 00:07:44,460

there for right now so this was

216

00:07:48,580 --> 00:07:46,490

promising to us we also see methanogens

217

00:07:51,409 --> 00:07:48,590

distributed throughout the system

218

00:07:53,480 --> 00:07:51,419

however when we come in and we start to

219

00:07:55,400 --> 00:07:53,490

look at the geochemistry of the fluids

220

00:07:57,830 --> 00:07:55,410

and just the methane alone it's often

221

00:07:59,810 --> 00:07:57,840

quite confounding in terms of how to

222

00:08:01,730 --> 00:07:59,820

interpret the data so this is some work

223

00:08:03,440 --> 00:08:01,740

from Dan no chaffed and in this

224

00:08:05,900 --> 00:08:03,450

particular case what he's plotting is

225

00:08:10,850 --> 00:08:05,910

the Delta 13c of methane against c1 over

226

00:08:13,250 --> 00:08:10,860

c2 plus c3 alkanes in our surface

227

00:08:15,650 --> 00:08:13,260

fractured shallow mixed water kind of

228

00:08:17,210 --> 00:08:15,660

aquifers we get pulses of methane out

229

00:08:19,010 --> 00:08:17,220

and they're easily recognized as

230

00:08:21,050 --> 00:08:19,020

microbial we also get these higher rates

231

00:08:23,690 --> 00:08:21,060

of microbial methanogenesis there

232

00:08:25,850 --> 00:08:23,700

there's really no question however when

233

00:08:28,250 --> 00:08:25,860

we move to the closed system hyper

234

00:08:30,350 --> 00:08:28,260

alkaline part we have this enormous flip

235

00:08:32,060 --> 00:08:30,360

in terms of the Delta 13c of methane

236

00:08:35,540 --> 00:08:32,070

we're often sitting right around zero or

237

00:08:37,399 --> 00:08:35,550

per mil and it's very enigmatic to

238

00:08:38,420 --> 00:08:37,409

interpret it in terms of its origin and

239

00:08:40,339 --> 00:08:38,430

source but one of the things that's

240

00:08:42,800 --> 00:08:40,349

notable is when you look at c1 over they

241

00:08:44,960 --> 00:08:42,810

see two plus c3 work 10 to the 2 to 10

242

00:08:46,579 --> 00:08:44,970

to the 5 in terms of enrichment and it

243

00:08:48,170 --> 00:08:46,589

again points to this potential for a

244

00:08:50,390 --> 00:08:48,180

microbial source but we need to have

245

00:08:53,870 --> 00:08:50,400

other ways to assess and discriminate

246

00:08:55,310 --> 00:08:53,880

that and it would be surprising to be

247

00:08:57,319 --> 00:08:55,320

surprising to have methane with

248

00:08:58,319 --> 00:08:57,329

compositions as heavy as this that may

249

00:09:00,449 --> 00:08:58,329

be generated through by

250

00:09:02,429 --> 00:09:00,459

logical activity particularly because

251

00:09:04,319 --> 00:09:02,439

this is the state of the fluids also in

252

00:09:06,780 --> 00:09:04,329

which we're looking and trying to probe

253

00:09:08,160 --> 00:09:06,790

the activity of methanogens sitting at

254

00:09:10,379 --> 00:09:08,170

the lower stability limit of water

255

00:09:13,619 --> 00:09:10,389

sitting across these alkaline to hyper

256

00:09:15,030 --> 00:09:13,629

alkaline pH in very limited di C but

257

00:09:16,829 --> 00:09:15,040

these are in rocks that have undergone

258

00:09:18,960 --> 00:09:16,839

significant water rock reaction and are

259

00:09:22,829 --> 00:09:18,970

carbonated even though it's a low level

260

00:09:24,569 --> 00:09:22,839

of carbonation throughout so coming back

261

00:09:25,949 --> 00:09:24,579

to the geochemical parameters one of the

262

00:09:27,840 --> 00:09:25,959

things that dan did is he worked with

263

00:09:30,269 --> 00:09:27,850

both Shuhei owners lab and then with ed

264

00:09:32,489 --> 00:09:30,279

young ed young's lab trying to look at

265

00:09:34,559 --> 00:09:32,499

the clumped isotope systematics of the

266

00:09:36,539 --> 00:09:34,569

methane when we started this project the

267

00:09:39,269 --> 00:09:36,549

only parameter available to us here was

268

00:09:41,639 --> 00:09:39,279

looking at the cap 13 CH 3 d component

269

00:09:43,019 --> 00:09:41,649

and we're just looking at this case at

270

00:09:45,509 --> 00:09:43,029

different systems at what would be an

271

00:09:47,789 --> 00:09:45,519

isotopic equilibrium and in this case we

272

00:09:50,729 --> 00:09:47,799

have again significant bond disorder and

273

00:09:53,699 --> 00:09:50,739

it in a partitioning methane here that

274

00:09:55,949 --> 00:09:53,709

looks like it's microbial in nature this

275

00:09:59,220 --> 00:09:55,959

year we were able to get an extra lens

276

00:10:02,160 --> 00:09:59,230

into this through the cap 12 ch2 D 2 as

277

00:10:03,900 --> 00:10:02,170

well as in this kinds of systems and in

278

00:10:05,609 --> 00:10:03,910

this case this would be an array for

279

00:10:07,679 --> 00:10:05,619

both low to high temperature isotope

280

00:10:09,569 --> 00:10:07,689

equilibrium but when we're looking at

281

00:10:11,819 --> 00:10:09,579

these two rare mouse 18 isotopologues

282

00:10:14,340 --> 00:10:11,829

this would be for example data from Kidd

283

00:10:16,319 --> 00:10:14,350

Creek but this is the microbial array in

284

00:10:19,799 --> 00:10:16,329

a Mons plotting squarely within that as

285

00:10:21,239 --> 00:10:19,809

well from this lens so coming back to

286

00:10:23,909 --> 00:10:21,249

then trying to probe these systems in

287

00:10:25,829 --> 00:10:23,919

terms of the active biology Emily Krause

288

00:10:28,319 --> 00:10:25,839

gave a talk here earlier this week on

289

00:10:30,449 --> 00:10:28,329

Tuesday where she's going in and pulling

290

00:10:33,329 --> 00:10:30,459

DNA and out of these highly reduced

291

00:10:36,119 --> 00:10:33,339

hyper alkaline fluids and in sequencing

292

00:10:38,639 --> 00:10:36,129

in in this particular set of samples

293

00:10:40,499 --> 00:10:38,649

that we've had recently the remember

294

00:10:42,479 --> 00:10:40,509

again I had 10 to the 5 cells per mil as

295

00:10:44,999 --> 00:10:42,489

an average number across the system and

296

00:10:46,859 --> 00:10:45,009

now we have 10 to almost 20% of the

297

00:10:49,079 --> 00:10:46,869

total 16s reads are from methane a

298

00:10:51,419 --> 00:10:49,089

bacterium that's present that's a pretty

299

00:10:53,159 --> 00:10:51,429

abundant methanogenic population and

300

00:10:55,199 --> 00:10:53,169

these hyper alkaline reduced fluids and

301
00:10:56,699 --> 00:10:55,209
then in this other axis here what she's

302
00:10:59,280 --> 00:10:56,709
looking at is that is the number of

303
00:11:01,499 --> 00:10:59,290
transcripts and so the methanogens are

304
00:11:03,720 --> 00:11:01,509
by far the active population under this

305
00:11:05,519 --> 00:11:03,730
condition so we are getting a number of

306
00:11:06,960 --> 00:11:05,529
metrics that are telling us they're here

307
00:11:08,369 --> 00:11:06,970
and they're busy and they are making

308
00:11:09,749 --> 00:11:08,379
methane and we're capturing and

309
00:11:11,970 --> 00:11:09,759
collecting that with a pretty strong

310
00:11:15,330 --> 00:11:11,980
signal from both the geochemical by

311
00:11:17,640 --> 00:11:15,340
illogical space we have been very

312
00:11:19,470 --> 00:11:17,650
fortunate working here that him we had

313
00:11:21,780 --> 00:11:19,480

done targeted culturing that started a

314

00:11:24,480 --> 00:11:21,790

few years ago going after within

315

00:11:26,280 --> 00:11:24,490

methanogenesis and we do have one of the

316

00:11:27,900 --> 00:11:26,290

mechanism bacterium in culture that's

317

00:11:29,640 --> 00:11:27,910

present in the system so Dan Coleman is

318

00:11:31,320 --> 00:11:29,650

actually mapping out the differential

319

00:11:33,540 --> 00:11:31,330

distribution of methane a bacterium

320

00:11:35,700 --> 00:11:33,550

across the system this is one of the

321

00:11:37,710 --> 00:11:35,710

math in a bacterium that we see and

322

00:11:40,050 --> 00:11:37,720

Hannah Miller was able to then start to

323

00:11:41,910 --> 00:11:40,060

grow it in the laboratory where she was

324

00:11:43,590 --> 00:11:41,920

providing it with a variety of carbon

325

00:11:45,930 --> 00:11:43,600

sources including trying to grow it on

326

00:11:48,270 --> 00:11:45,940

calcium carbonate and the idea here is

327

00:11:50,520 --> 00:11:48,280

with this particular isolate she's able

328

00:11:52,740 --> 00:11:50,530

to grow it much more easily in these

329

00:11:55,020 --> 00:11:52,750

more alkaline pH high D icy conditions

330

00:11:56,520 --> 00:11:55,030

but she can push it to higher pH and

331

00:11:58,680 --> 00:11:56,530

slower growth rates but still get

332

00:12:01,200 --> 00:11:58,690

persistent methane formation and see a

333

00:12:03,750 --> 00:12:01,210

huge shift in the Delta 13c of methane

334

00:12:05,850 --> 00:12:03,760

that's that increases by over 50 per mil

335

00:12:07,740 --> 00:12:05,860

and that's just a simple function of

336

00:12:08,910 --> 00:12:07,750

carbon limitation and availability in

337

00:12:10,830 --> 00:12:08,920

that system but it's such a strong

338

00:12:13,730 --> 00:12:10,840

switch that's flipping us in terms of

339

00:12:16,410 --> 00:12:13,740

what that bulk isotope characteristic is

340

00:12:18,570 --> 00:12:16,420

so to give an image of that order

341

00:12:19,830 --> 00:12:18,580

visioning is that back in the field site

342

00:12:21,210 --> 00:12:19,840

type of system is that when we're

343

00:12:23,190 --> 00:12:21,220

looking in areas where there's been this

344

00:12:24,840 --> 00:12:23,200

prior carbonation even though there's

345

00:12:27,090 --> 00:12:24,850

very little di C and we're sitting in

346

00:12:29,130 --> 00:12:27,100

hyper alkaline pH the rate and soluble

347

00:12:31,950 --> 00:12:29,140

ization of calcium carbonates very low

348

00:12:33,870 --> 00:12:31,960

but we must have a coupled acquisition

349

00:12:35,820 --> 00:12:33,880

system here which is allowing there to

350

00:12:38,100 --> 00:12:35,830

be the solubilization up taken almost

351

00:12:39,960 --> 00:12:38,110

quantitative conversion of that co2 into

352

00:12:41,460 --> 00:12:39,970

methane and that's something that we're

353

00:12:44,700 --> 00:12:41,470

now trying to probe and get at the rates

354

00:12:46,410 --> 00:12:44,710

for and just listening to san jose talk

355

00:12:48,480 --> 00:12:46,420

earlier today because it is fun to try

356

00:12:49,590 --> 00:12:48,490

and integrate through the week it's been

357

00:12:52,560 --> 00:12:49,600

really interesting to have these

358

00:12:55,080 --> 00:12:52,570

discussions about the km for the fan of

359

00:12:57,210 --> 00:12:55,090

genesis for this step for co2

360

00:12:59,010 --> 00:12:57,220

acquisition and to think about whether

361

00:13:00,900 --> 00:12:59,020

or not this organism or some of the ones

362

00:13:03,180 --> 00:13:00,910

that are adapted in here maybe do have a

363

00:13:04,560 --> 00:13:03,190

different km that affects some of the

364

00:13:07,800 --> 00:13:04,570

energetics and that's something that

365

00:13:09,660 --> 00:13:07,810

hasn't been directly tested or probed so

366

00:13:12,480 --> 00:13:09,670

just a the last part of this talk and

367

00:13:13,380 --> 00:13:12,490

just have a slider to to also connect to

368

00:13:15,360 --> 00:13:13,390

some of the work we've been doing

369

00:13:17,700 --> 00:13:15,370

looking at sulfate reduction so this is

370

00:13:19,560 --> 00:13:17,710

with Clemens Columbia who is an NP P

371

00:13:22,090 --> 00:13:19,570

postdoc in Torrey holers lab at NASA

372

00:13:24,490 --> 00:13:22,100

Ames and

373

00:13:26,499 --> 00:13:24,500

is another incredibly Astra biologically

374

00:13:28,629 --> 00:13:26,509

irrelevant metabolism for these systems

375

00:13:30,639 --> 00:13:28,639

looking at sulfate as the dominant

376

00:13:32,290 --> 00:13:30,649

electron acceptor not only with hydrogen

377

00:13:34,090 --> 00:13:32,300

but also with the micro molar

378

00:13:35,860 --> 00:13:34,100

concentrations of organic acids we

379

00:13:38,499 --> 00:13:35,870

detect in these systems as well as with

380

00:13:40,569 --> 00:13:38,509

the abundant methane and so clemens

381

00:13:42,370 --> 00:13:40,579

systematically started probing the fluid

382

00:13:44,110 --> 00:13:42,380

system to start with a 35 labelled

383

00:13:45,910 --> 00:13:44,120

sulfate to try and probe the

384

00:13:49,870 --> 00:13:45,920

distribution of sulfate reduction

385

00:13:51,970 --> 00:13:49,880

activity and in general he has very low

386

00:13:54,220 --> 00:13:51,980

rates so pica moles per mils per day

387

00:13:56,379 --> 00:13:54,230

he's worked in deep sea sediments in

388

00:13:58,240 --> 00:13:56,389

different parts of the globe and these

389

00:14:00,249 --> 00:13:58,250

are exceedingly low rates but he has

390

00:14:02,710 --> 00:14:00,259

been able to see them persistent but

391

00:14:04,720 --> 00:14:02,720

they are really diminished in the hyper

392

00:14:06,340 --> 00:14:04,730

alpha state of the system so unlike

393

00:14:07,689 --> 00:14:06,350

methane aogenesis sulfate reduction is

394

00:14:09,639 --> 00:14:07,699

actually the one heating up against a

395

00:14:14,350 --> 00:14:09,649

wall in ways we don't understand

396

00:14:15,819 --> 00:14:14,360

once we get above pH of 10 now that

397

00:14:17,470 --> 00:14:15,829

we've done the drilling into the deep

398

00:14:19,150 --> 00:14:17,480

and we are starting to look as a

399

00:14:21,069 --> 00:14:19,160

function of depth and and again

400

00:14:23,920 --> 00:14:21,079

geochemical states of the system and the

401
00:14:25,600 --> 00:14:23,930
subsurface Clemens has again been

402
00:14:27,670 --> 00:14:25,610
probing these cores to look at the

403
00:14:29,829 --> 00:14:27,680
differential distribution of sulfate

404
00:14:31,509 --> 00:14:29,839
reduction activity so in just one of the

405
00:14:34,269 --> 00:14:31,519
course that we've been starting to work

406
00:14:36,129 --> 00:14:34,279
on and this this would be go from zero

407
00:14:38,530 --> 00:14:36,139
to 400 meters of depth or at least this

408
00:14:39,840 --> 00:14:38,540
core does he probed a series of

409
00:14:41,740 --> 00:14:39,850
different depths and has a clear

410
00:14:44,379 --> 00:14:41,750
localization of where sulfate reduction

411
00:14:46,420 --> 00:14:44,389
is occurring we have down whole logs

412
00:14:49,960 --> 00:14:46,430
that allow us to look at the pH and the

413
00:14:51,610 --> 00:14:49,970

redox h of these fluids and what we're

414

00:14:53,620 --> 00:14:51,620

really finding is that once that's a

415

00:14:56,110 --> 00:14:53,630

reducing condition but we dropped down

416

00:14:58,210 --> 00:14:56,120

below pH 10 or 10 and a half we can see

417

00:14:59,740 --> 00:14:58,220

the sulfate reduction kick in and it's

418

00:15:02,110 --> 00:14:59,750

being suppressed elsewhere in this

419

00:15:03,670 --> 00:15:02,120

course so this is giving us some

420

00:15:05,559 --> 00:15:03,680

guideposts now and other work that's

421

00:15:06,879 --> 00:15:05,569

ongoing such as KT REM fritz talked

422

00:15:09,129 --> 00:15:06,889

earlier this week where she's been

423

00:15:10,749 --> 00:15:09,139

looking at the intact polar lipid

424

00:15:12,220 --> 00:15:10,759

distribution in these samples this has

425

00:15:14,530 --> 00:15:12,230

been a great place for her to work to

426

00:15:16,990 --> 00:15:14,540

prove that she can really extract and

427

00:15:19,360 --> 00:15:17,000

start to characterize IPL's from these

428

00:15:21,670 --> 00:15:19,370

kinds of cores and detect them well in a

429

00:15:26,129 --> 00:15:21,680

but in excess of any contamination in

430

00:15:28,580 --> 00:15:26,139

these kinds of systems so to conclude

431

00:15:30,830 --> 00:15:28,590

we're at the beginning

432

00:15:32,990 --> 00:15:30,840

and we're really feeling like we've now

433

00:15:35,660 --> 00:15:33,000

starting to understand components of how

434

00:15:39,320 --> 00:15:35,670

the system is set up that we can begin

435

00:15:41,300 --> 00:15:39,330

to really aggressively delineate where

436

00:15:43,370 --> 00:15:41,310

different microbial metabolisms are

437

00:15:44,690 --> 00:15:43,380

functionally active and start working on

438

00:15:46,940 --> 00:15:44,700

pulling out and exploring the

439

00:15:48,950 --> 00:15:46,950

physiological adaptations to hyper

440

00:15:50,630 --> 00:15:48,960

alkaline pH and thus extreme carbon

441

00:15:54,530 --> 00:15:50,640

limitation and the differential

442

00:15:56,780 --> 00:15:54,540

abundance and activity of populations we

443

00:15:58,280 --> 00:15:56,790

are very interested in both the total

444

00:15:59,840 --> 00:15:58,290

community but the active microbial

445

00:16:01,670 --> 00:15:59,850

community in these very differences

446

00:16:03,680 --> 00:16:01,680

parts of the system that more Open Mixed

447

00:16:05,870 --> 00:16:03,690

chemical environment and then what's

448

00:16:07,850 --> 00:16:05,880

sealed in to the more static aspect of

449

00:16:09,950 --> 00:16:07,860

the system but is able to slowly persist

450

00:16:11,480 --> 00:16:09,960

and all of those of course are going to

451
00:16:13,610 --> 00:16:11,490
lend themselves to trying to identify

452
00:16:15,740 --> 00:16:13,620
the bio markers and the bio signatures

453
00:16:17,180 --> 00:16:15,750
of that activity we have to keep nesting

454
00:16:19,340 --> 00:16:17,190
in at these different scales to come

455
00:16:20,570 --> 00:16:19,350
find that but our search strategy for

456
00:16:22,790 --> 00:16:20,580
life and actually trying to represent

457
00:16:25,040 --> 00:16:22,800
the chemical and the biological measures

458
00:16:34,730 --> 00:16:25,050
of that life activity is looking really

459
00:16:36,140 --> 00:16:34,740
promising so thank you very much Lexus

460
00:16:39,860 --> 00:16:36,150
we have time for a few questions for

461
00:16:41,780 --> 00:16:39,870
Alexis you mentioned kick Creek in the

462
00:16:44,890 --> 00:16:41,790
clumped isotopes and then with the

463
00:16:49,970 --> 00:16:44,900

sulfate reduction you also sure that

464

00:16:52,400 --> 00:16:49,980

methane goes to bicarbonate he's there a

465

00:16:55,550 --> 00:16:52,410

carbon cycling there that I mean how

466

00:16:57,710 --> 00:16:55,560

does that fit into the I forget exactly

467

00:17:00,140 --> 00:16:57,720

what you said in reference to the where

468

00:17:04,310 --> 00:17:00,150

your data fit into the Kid Greek but are

469

00:17:06,080 --> 00:17:04,320

there McDonald robes you know coupled to

470

00:17:10,190 --> 00:17:06,090

suffered silver that affect the club

471

00:17:11,780 --> 00:17:10,200

Ascalon yeah I mean it's in the overall

472

00:17:14,510 --> 00:17:11,790

question of what you're asking

473

00:17:16,070 --> 00:17:14,520

we have a really complex carbon cycle

474

00:17:16,970 --> 00:17:16,080

occurring here and we're just feeling

475

00:17:19,370 --> 00:17:16,980

like we're starting to have the right

476

00:17:21,110 --> 00:17:19,380

data to tease it out so especially in

477

00:17:23,090 --> 00:17:21,120

places where there's no measurable di C

478

00:17:24,890 --> 00:17:23,100

there's a lot of questions about what's

479

00:17:26,990 --> 00:17:24,900

the real form of carbon being taken up

480

00:17:28,880 --> 00:17:27,000

by cells and being used so co₂ is one

481

00:17:31,220 --> 00:17:28,890

option we have this discussion about the

482

00:17:35,090 --> 00:17:31,230

km but we're really looking at formate

483

00:17:37,010 --> 00:17:35,100

and co availability and its role and a

484

00:17:39,310 --> 00:17:37,020

potentially for example of the math and

485

00:17:40,980 --> 00:17:39,320

Genesis or in sulfate-reducing

486

00:17:43,169 --> 00:17:40,990

populations

487

00:17:44,789 --> 00:17:43,179

but um we have to start to really trace

488

00:17:47,100 --> 00:17:44,799

that elegantly and we've had to know

489

00:17:48,720 --> 00:17:47,110

where and how to do that so I think

490

00:17:50,370 --> 00:17:48,730

we're tip of the iceberg and trying to

491

00:17:52,350 --> 00:17:50,380

really understand the balance of how

492

00:17:54,690 --> 00:17:52,360

we're both producing and REE consuming

493

00:17:56,310 --> 00:17:54,700

co2 and where these different

494

00:17:58,019 --> 00:17:56,320

populations are active it's weird that

495

00:17:59,970 --> 00:17:58,029

we can shut the sulfate reduction down

496

00:18:02,010 --> 00:17:59,980

above pH 10 and really not be able to

497

00:18:04,130 --> 00:18:02,020

detect it that allows us to separate

498

00:18:06,810 --> 00:18:04,140

sulfate reduction in the methanogens

499

00:18:08,460 --> 00:18:06,820

activity at the higher pH conditions and

500

00:18:13,850 --> 00:18:08,470

we put them back together in the

501
00:18:16,649 --> 00:18:13,860
moderate moderate pH 10 9 can it realm

502
00:18:23,460 --> 00:18:16,659
no time for another question Alexis

503
00:18:26,909 --> 00:18:23,470
there are others thanks for the great

504
00:18:28,470 --> 00:18:26,919
talk I have a related question but maybe

505
00:18:32,039 --> 00:18:28,480
it's too specific but I'm curious about

506
00:18:33,750 --> 00:18:32,049
it if you have any insights as to the

507
00:18:36,630 --> 00:18:33,760
membrane bioenergetics of these

508
00:18:39,000 --> 00:18:36,640
organisms because one of the persistent

509
00:18:42,000 --> 00:18:39,010
questions is the PMF or is it a sodium

510
00:18:44,190 --> 00:18:42,010
motive force or do you guys have any new

511
00:18:46,409 --> 00:18:44,200
data about that we don't have new data

512
00:18:48,539 --> 00:18:46,419
about that what we are doing is actually

513
00:18:50,190 --> 00:18:48,549

using data from some of the work Dan

514

00:18:53,010 --> 00:18:50,200

Coleman's been doing which isn't shown

515

00:18:55,560 --> 00:18:53,020

here trying to come back in and actually

516

00:18:57,659 --> 00:18:55,570

we retarget the isolation of the meth

517

00:18:59,370 --> 00:18:57,669

ana bacterium that is functioning well

518

00:19:00,360 --> 00:18:59,380

in the hyper alkaline component of the

519

00:19:01,919 --> 00:19:00,370

systems the one that's really

520

00:19:03,240 --> 00:19:01,929

differentially distributed there and

521

00:19:05,220 --> 00:19:03,250

that one want to be a more appropriate

522

00:19:06,299 --> 00:19:05,230

one to do this I'm also really

523

00:19:09,060 --> 00:19:06,309

interested generally with the

524

00:19:09,960 --> 00:19:09,070

methanogens what the Delta pH is between

525

00:19:11,549 --> 00:19:09,970

the external and the internal

526

00:19:12,960 --> 00:19:11,559

environment and I think we really need a

527

00:19:15,570 --> 00:19:12,970

good measure of what is that

528

00:19:17,310 --> 00:19:15,580

intracellular pH which is also a part of

529

00:19:19,200 --> 00:19:17,320

them that is membrane bioenergetics so

530

00:19:20,940 --> 00:19:19,210

we're thinking about that but how to do

531

00:19:23,010 --> 00:19:20,950

this well and we really would like to

532

00:19:24,779 --> 00:19:23,020

move beyond the with antigen with an

533

00:19:26,279 --> 00:19:24,789

effect you and we have in culture and go

534

00:19:30,720 --> 00:19:26,289

after the one that we think is more

535

00:19:31,850 --> 00:19:30,730

physiologically adapted right thank you

536

00:19:33,810 --> 00:19:31,860

all XS